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Title: *A Unifying Strategy for Data Integration for Global Force Management*

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A Unifying Strategy for Data Integration for Global Force Management

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Abstract

Global operations in a network centric environment require high-resolution, richly populated force management data, constructs and management processes that extend across Service boundaries. This paper presents an approach that is based upon three pillars. First, realistically, the only way to maintain force structure data is to obtain it directly from the agencies responsible for building and maintaining that data. This requires that the people who develop and maintain force structure data in the Services and for the DOD must provide it in a form conducive to computer manipulation for use by a diverse population of users. Second, force structure data must be formally and rigorously specified and its semantics unambiguously defined and implemented so that sophisticated computer programs can economically exploit it. Finally, a common naming convention must be accepted across the Services with the capability of being extended through coalition boundaries. This paper presents a set of fundamental constructs and a description of how they can be manipulated to accomplish the objectives of the Global Force Management (GFM) process.

1. The Global Force Management Process Data Strategy

In the summer of 2003, the US Department of Defense (DOD) Joint Staff, Force Structure Directorate (J-8)[1] and the readiness portion of the Office of the Under-Secretary of Defense for Personnel and Readiness (USD(P&R))[2] established a Community of Interest for GFM (GFM-COI) to tackle the challenges imposed by the Net-Centric Data Strategy[3]. A major impetus for the establishment of the GFM-COI was the development of reliable and maintainable data sources for the new Defense Readiness Reporting System (DRRS).[4] Consequently, the objectives of the GFM-COI and DRRS overlap in many areas. To accomplish these aggressive goals, two sub-tasks were established. The first addresses the data itself. This includes the identification of major data attributes, their instantiation, maintainability, and structure. The second sub-task

[1] See: http://www.dtic.mil/jcs/core/j8.html
[2] See: http://www.dod.mil/prhome/readiness.html
[3] See: http://www.defenselink.mil/ nii/org/cio/doc/Net-Centric-Data-Strategy-2003-05-092.pdf
[4] See: http://www.dtic.mil/doctrine/training/29_drrs.ppt

focuses on ensuring that the data is accessible to the enterprise in a net-centric environment. This includes web-enabling data access and developing basic analysis tools. Both sub-tasks are currently being executed.

The GFM process strategy is based upon the tenet that force structure forms a foundational structure on which to integrate battle command and associated information.[5] This is illustrated in **Figure 1**. Ultimately, information about people, materiel, targeting, plans, communications, information security, program analysis and budgeting, and most other entities are linked by the concept of force structure. By defining and maintaining a rigorously defined force structure tree, straightforward algorithms can be developed to traverse the tree to collect and aggregate diverse information components that may not be anticipated before operations commence. This enables development of ad hoc programs that derive information from well-understood, often predefined associations, or to discover relationships between seemingly unrelated entities.

A major objective of the DRRS is to enable dynamic planning and rapid readiness assessment in a fast paced, net-centric world. This requires the ability to fuse current readiness status with mission planning and analysis processes to determine the capabilities of US units. To accomplish this goal, high resolution, accurate, and comprehensive force structure information is required

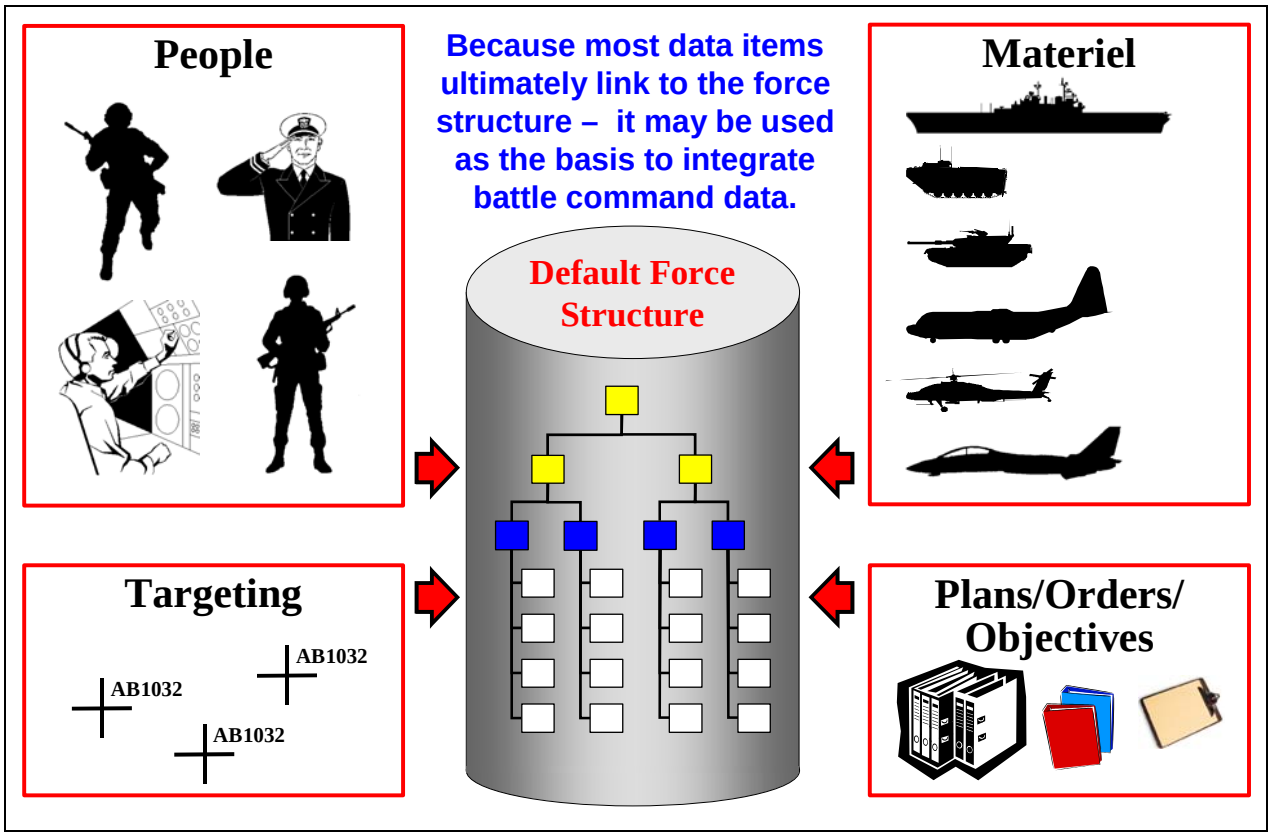

Figure 1: GFM Process Strategy - Force Structure Pulls Everything Together

[5] See Chamberlain, *Default Operational Representations of Military Organizations*, Army Research Laboratory Technical Report: ARL-TR-2172; February 2000; http://www.arl.army.mil/~wildman/PAPERS/tr2172.html

beyond that provided by the current Status of Readiness and Training System (SORTS) and its derivatives. To achieve this end state, the GFM-COI has commissioned the GFM Enterprise Data Initiative (EDI) to ensure the availability and sharing of force structure data and processes across the Services, including all active, reserve, and National Guard components, and civilian and contractor personnel.

The GFM-EDI concentrates on three topics. First, realistically, the only way to maintain force structure data is to obtain it directly from the agencies responsible for building and maintaining the data. This requires that the people who officially develop and maintain force structure data in the Services and for the DOD provide it in a form conducive to computer manipulation for use by a diverse population of users. This task is called Authoritative Data Source Identification and Authorization. Second, force structure data must be formally and rigorously specified and its semantics unambiguously defined and implemented to enable it to be used by sophisticated computer programs. To achieve this, a *GFM Force Structure Construct* (GFM-FSC) has been adopted and endorsed. Finally, a common naming convention must be accepted among the US Military Services with the capability of being extended across coalition boundaries.

2. Authoritative Data Source Identification

The first pillar is the most difficult. It requires the traditionally independent, Service force development communities to collaborate and cooperate with each other.[6] An obstacle familiar within all the Services is the historical division of the process of force structure development and maintenance into two tiers. This has produced a boundary at the lowest level of Unit Identification Code (UICs) assignment within each Service. It appears that this has occurred, in part, because it coincides with the lowest level of official command.[7] For example, in the Army and USMC it usually occurs at the Company echelon, in the Navy it is at the Ship or Squadron, and in the Air Force it is at the Squadron.

One meaning of the term *unit* is: any military element whose structure is prescribed by competent authority, such as a table of organization and equipment; specifically, part of an organization. [8] This implies that a unit is defined in part by the choice of echelon at which one aggregates entities for the purpose of documenting manpower and equipment. Historically, these echelons received UICs, as do the organizational entities above them. Consequently, there is an arbitrary documentation boundary that occurs at the lowest level of UIC assignment in each Service.[9] At and below this boundary force structure documents exist that define the aggregate details about manpower and equipment. For the Army and USMC, this is exemplified by the company MTOE and TO/TE, respectively; for the Navy, it is exemplified by the SMD for a ship or an SQMD for

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[6] Per Title 10 of the US Code, force development is inherently an internal Service task (see Sections: 3011, 5011, and 8011).

[7] *Command* (DOD): 1. The authority that a commander in the Armed Forces lawfully exercises over subordinates by virtue of rank or assignment. Command includes the authority and responsibility for effectively using available resources and for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel. From: http://www.dtic.mil/doctrine/jel/doddict/data/c/01080.html.

[8] *Unit* (DoD), from: http://www.dtic.mil/doctrine/jel/doddict/data/u/05570.html.

[9] The meaning of *arbitrary* as used here is: based on or determined by individual preference or convenience rather than by necessity or the intrinsic nature of something; from http://www.m-w.com.

an aviation squadron; and for the USAF, it is exemplified by a UMD for a squadron.[10] These documents contain the templates from which real units are instantiated and assigned UICs. Conversely, operational reporting systems, such as SORTS, begin at this level (with few exceptions) and extend upward. Therefore, the lowest UIC echelons form a jagged boundary, below which exists the manpower community (the *lower tier*) and above which resides the operations community (the *upper tier*), and each tier has its own set of authoritative data sources. This is illustrated in **Figure 2**.

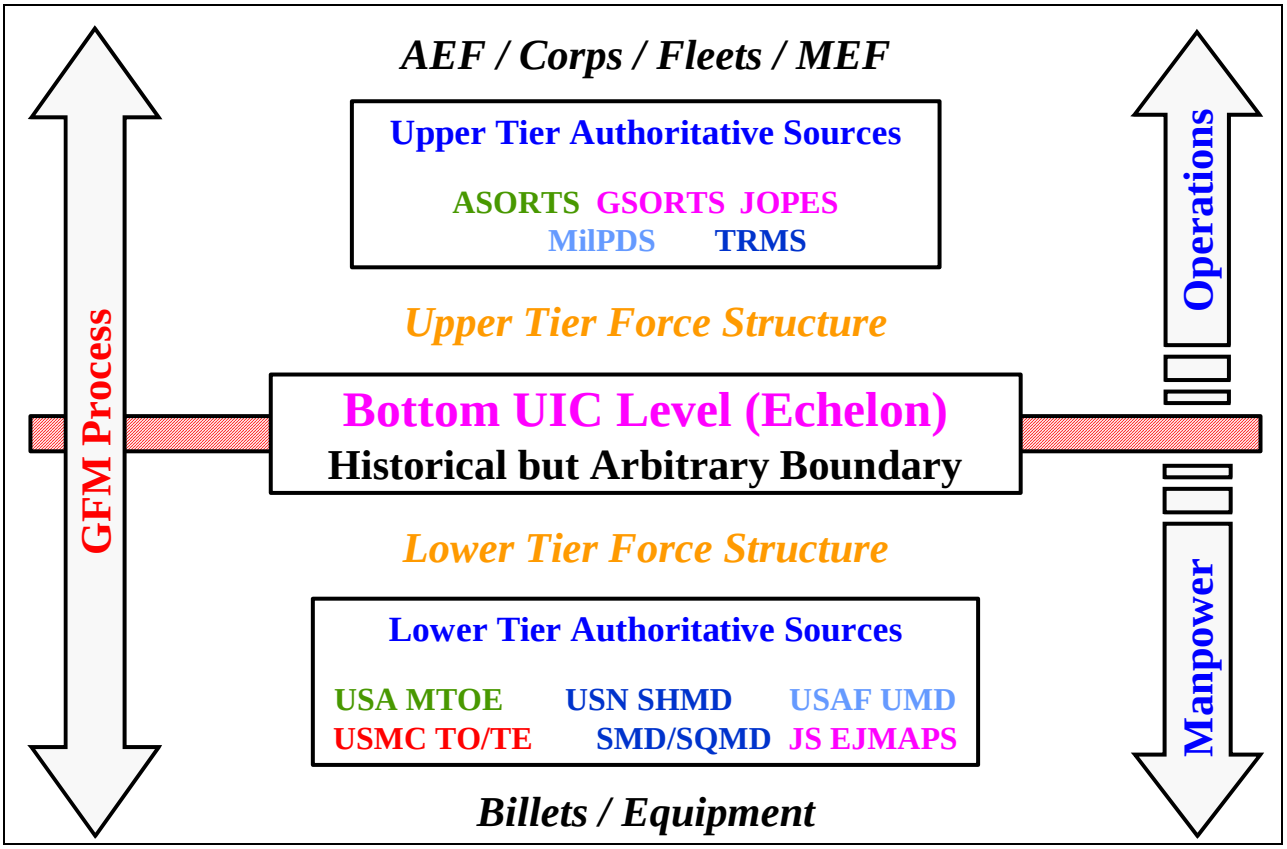

Figure 2: Upper Tier and Lower Tier Authoritative Data Sources

Authoritative data source identification in the lower tier is further compounded by the diversity of information included, namely, materiel and personnel authorization information. These items describe the number and type of equipment and personnel authorized for the unit.[11] In some cases, the lower tier force structure developers do not "own" this data; instead, it must be obtained from and exchanged with the personnel or logistics communities, thus confounding the authoritative source identification task.

[10] Definitions: MTOE – Modification Tables of Organization & Equipment; TO - Table of Organization; SMD – Ship Manpower Document; SQMD – Squadron Manpower Document; UMD – Unit Manpower Document.

[11] *Type* entities must not be confused with actual equipment (e.g., with serial numbers) or people (e.g., with Social Security Numbers).

Finally, in all the Services there is a common partition between *authorization* data and *status* data. The manpower and equipment documents of the lower tier (just described) contain authorization documents. They describe *what should be*, not *what is*. In the lower tier, status data includes the roster of people and inventory of equipment present (or available) to an organization. In the upper tier it contains the current task organization that defines the actual structure of deployed or operational units. **Figure 3** illustrates this partition. On the left are the data sources that contain baseline, authorization data. This data can be augmented with information about the actual people (e.g., the personnel roster) and equipment (the property book) present in the organization to produce status information; that is, the actual condition of the personnel and equipment. Traditionally, readiness is computed by a comparison of what should be to what is. However, DRRS seeks to expand the way US military units are evaluated to include the concept of "usability." Simply stated, usability compares a unit's status (both people and equipment) to the capability to produce an end-state, rather than to a baseline state. Usability is a different calculation from readiness, and metrics are just now being established to implement this significant change.

When the concepts presented in **Figure 2** & **Figure 3** are combined, one can understand the difficulty in identifying authoritative data sources (ADS). This is illustrated in **Figure 4** where the distinction between the upper and lower tiers is combined with that of authorization versus status data to create four quadrants labeled I through IV. Each quadrant has its own set of ADS's, often with different organizations and proponents maintaining them. An objective of the GFM process

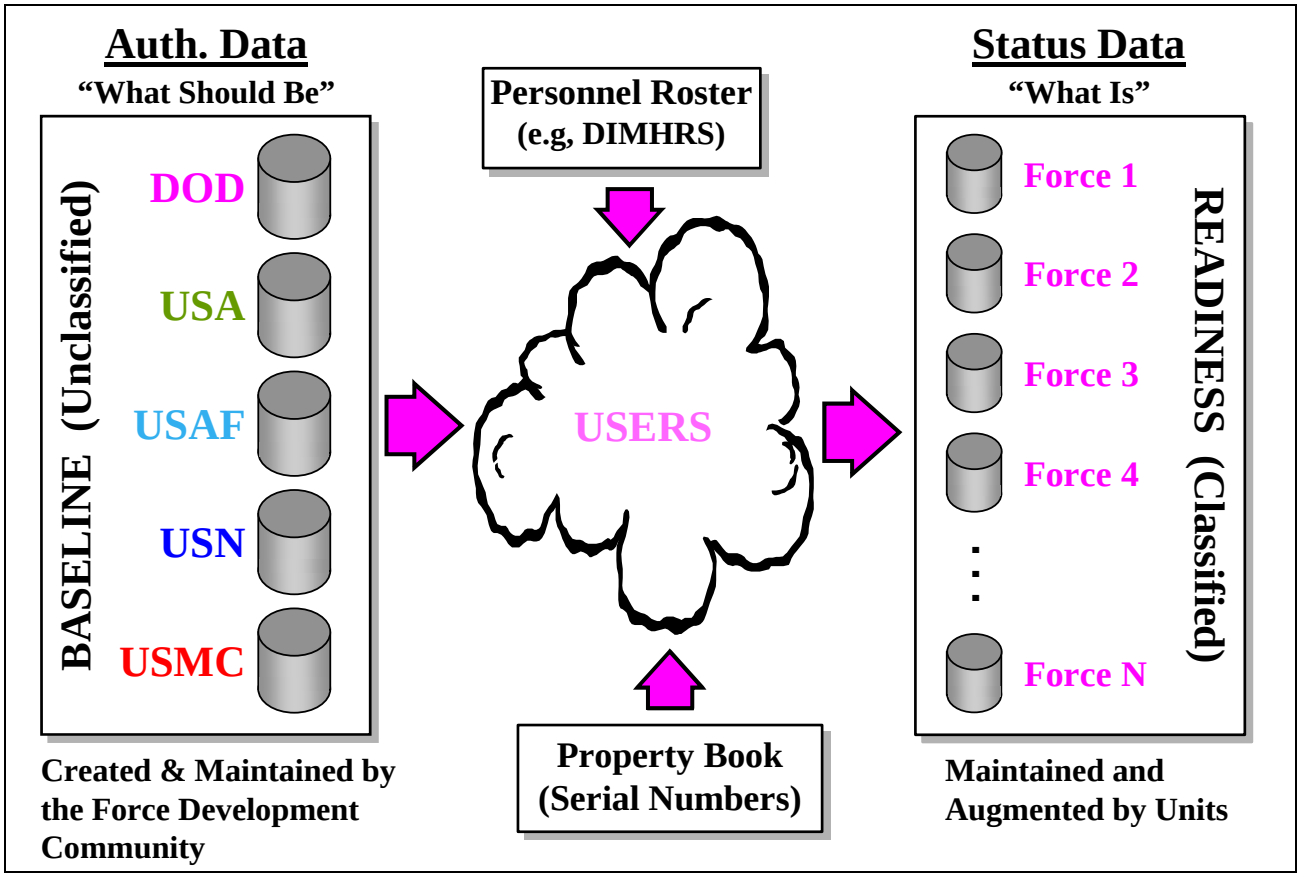

Figure 3: Authorization Data Versus Status Data

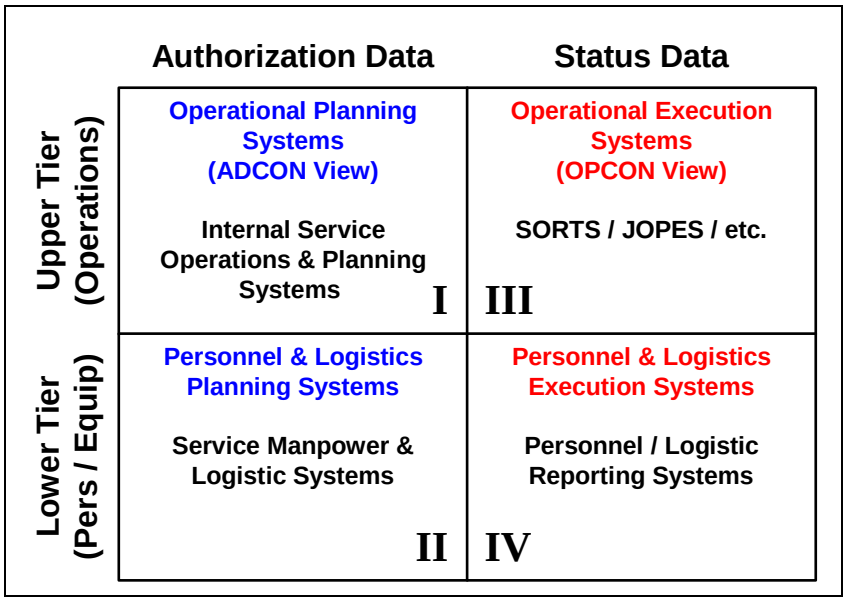

Figure 4: Four Quadrants of Force Structure Data Sources

is to pull these disparate data sources together into a seamless environment so that readiness, usability, and other information can be effectively and efficiently collected. Thus, the identification of authoritative sources of force structure data is a prerequisite to other tasks and objectives. The next section includes a description of how the unification of these four quadrants can be achieved.

3. The GFM Force Structure Construct

The second and third pillars of the GFM-EDI address the configuration and composition of force structure data. The objective of the second pillar is to provide a continuous, rigorously defined force structure tree that extends from the top-most echelon (e.g., DOD), across the UIC boundary, down to the individual billets. This tree structure does not require one to eliminate UICs, but does relegate them to artifacts that represent popular, but arbitrary, historical aggregation points that may eventually fade as their usefulness naturally wanes. This objective is achieved via the *GFM-FSC*. The remainder of this paper describes this construct.

The third pillar deals with data identification across the enterprise in an unpredictable, net-centric distribution environment. A simple, general-purpose scheme called Enterprise Identifiers, or EIDs, is proposed. The theory and implementation of EIDs has been documented in previous CCRP papers and will not be further described this document.[12]

3.1 The GFM FSC Strategy

The GFM-FSC strategy is based upon the tenet that the concept of force structure forms the foundation to which nearly all battle command data is ultimately linked. In simple terms, force

[12] See: http://www.dodccrp.org/Activities/Symposia/7thICCRTS/Tracks/pdf/109.PDF, http://www.arl.army.mil/~wildman/PAPERS/7thc2rt.html, or visit:https://ess.arl.army.mil.

structure pulls all other data together. Therefore, if a rigorous set of principles and constructs can be agreed upon across the Services to define force structure, it can be used as an integrating theme to pull together other data domains; recall **Figure 1**. Further, common algorithms and tools can be developed to traverse a force structure graph that is composed of entries from any Service.

The ultimate objective of the GFM-FSC is to provide rigorously defined, high-resolution, operational force structure data that is conducive to machine manipulation and usable by a diverse set of users. This includes systems used for battle command, personnel and logistics management, program analysis and budgeting, information security, and communications, just to name a few. Consequently, the data must conform to a set of simple principles and be general in nature.

The plan is to begin by addressing the data in Quadrants I and II of **Figure 4.** The data from these two quadrants is merged and maintained in databases called Organization Servers (org servers) that are controlled by the Services. The org servers contain default force structure data that extends down to the billet level and function as the definitive source for authorization data at all echelons of the Service. Clearly, the data in the org servers must traverse the traditional upper/lower tier boundary, and this is accomplished using a continuous tree structure that is described by the GFM-FSC. Further, the data is time-based so that the Services can maintain multiple years of force structure data in a server. This is accomplished by including a time interval in every node and link of the graph that defines when the entity is viable. The graph may be traversed using a specified time to filter out those links (and nodes) whose time period does not include the specified time.[13] This allows mutually exclusive sets of links (based on time) that define different org trees at different points in time to coexist in a server. Once the org servers are developed, the systems that comprise the domains defined by Quadrants III & IV can download the default force structure from the org servers and associate their real world, status data with it. Thus, the default data provided by the Service org servers becomes a central foundation on which the other domains can associate their data, thereby integrating it into the global picture.

3.2 GFM-FSC – Default Operational Organizations

The fundamental product of the GFM FSC is a rigorously defined force structure tree. The tree conforms to the mathematical definition of a tree graph that contains a set of nodes and links, each with an associated time period that defines when the node or link is viable. As time progresses, a node or link continues to be viable if its end-time is increased to keep pace with the time progression. In force structure vernacular, the nodes are named *organizations* and a set of links is named a *command structure*. In this formalism, a set of organizations with a command structure is called a *unit*. An organization is a virtual entity in the sense that it does not physically exist. One cannot "touch" an organization; it is merely a mental grouping of real objects.[14] Perhaps the most basic function of an organization is to serve as an aggregation point for other entities, in this case, other organizations, materiel, or personnel. In this regard, the default meaning of the links of a command structure is aggregation, and a link may be verbally interpreted using the words "is-composed-of (e.g., Unit A *is-composed-of* Organizations B, C, and D)."

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[13] Chamberlain, Sam (ARL); Leeds, Chris (USAFMSA); *Time-Based Tree Graphs for Stabilized Force Structure Representations*; Proceedings of the 8th International Command and Control Research and Technology Symposium; National Defense University, Ft McNair, Washington DC; 17-19 June 2003; See: http://www.dodccrp.org/events/2003/8th_ICCRTS/pdf/086.pdf.

[14] This is why organization charts are structured in so many different ways. They reflect diverse perceptions.

One reason for the GFM-FSC is to provide a process to produce a stable set of organizations with a default command structure from which other trees (i.e., new units) can be constructed by re-linking the set of organizations. In other words, it produces a set of *stable nodes* with *dynamic links*. To accomplish this, the set of organizational nodes must include those operational organizations required to accomplish the expected tasks and missions assigned to a unit. This set of organizations is called the set of Default Operational Organizations, or DOO.

An organization is created to serve as an aggregation point for other entities; therefore, it may be categorized based upon the reason for its creation. To date, three categories have been defined:

Billet: created for the purpose of employing a single person. A billet may not be composed of other organizations, and therefore, must be a leaf (i.e., terminal) node in an org tree. An association may be created between a person and a billet to represent the occupation of the billet by the person.

Crew: created for the purpose of employing a piece of materiel requiring operation by one or more persons. Crew membership and associations with equipment may be habitual or non-habitual (e.g., ad hoc).

Doctrinal: created for the purpose of employing doctrine, tactics, techniques, or procedures.

At any given time in the org server, there is a single command structure that is considered the default for the set of DOOs.[15] The time period of a default is typically several months, and it is modified in concert with force structure authorization updates (e.g., semi-annually or annually). User systems, such as battle command systems, use the default force structure as initialization data and download it from the org servers.[16] This is the GFM vision for all the Services and agencies of the DOD.

The default force structure includes the time-based, default organization tree that extends down to the billet level, the organization templates from which the organization tree was constructed, and the associated amounts of types of equipment authorized and the qualification requirements for the people who fill the billets. Therefore, this data reflects the state of a unit's planned, or ideal, status if all the right people are present with all of their equipment. Clearly, this ideal state is rarely (if ever) achieved.

To this "perfect," default force structure, a myriad of other information may be associated. Real people may be associated with the billets they fill; this provides the bond between the operational and personnel communities. In the traditional readiness context, one can easily compare the qualifications required of the billets with those of the people occupying the billets. Similarly, information about real equipment can be attached to the org tree at the appropriate places, and this too may be compared with the perfect world of authorized equipment.

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[15] The term "stationary data" is used to describe data that is not static, but whose expected periodicity is known and is long enough to allow the data to be treated as static; for example, it may be stored in a server for downloading.

[16] This may be direct, or more likely, implemented using an intermediate server that verifies the data and adds other, locally maintained data, such as personnel and equipment initialization data.

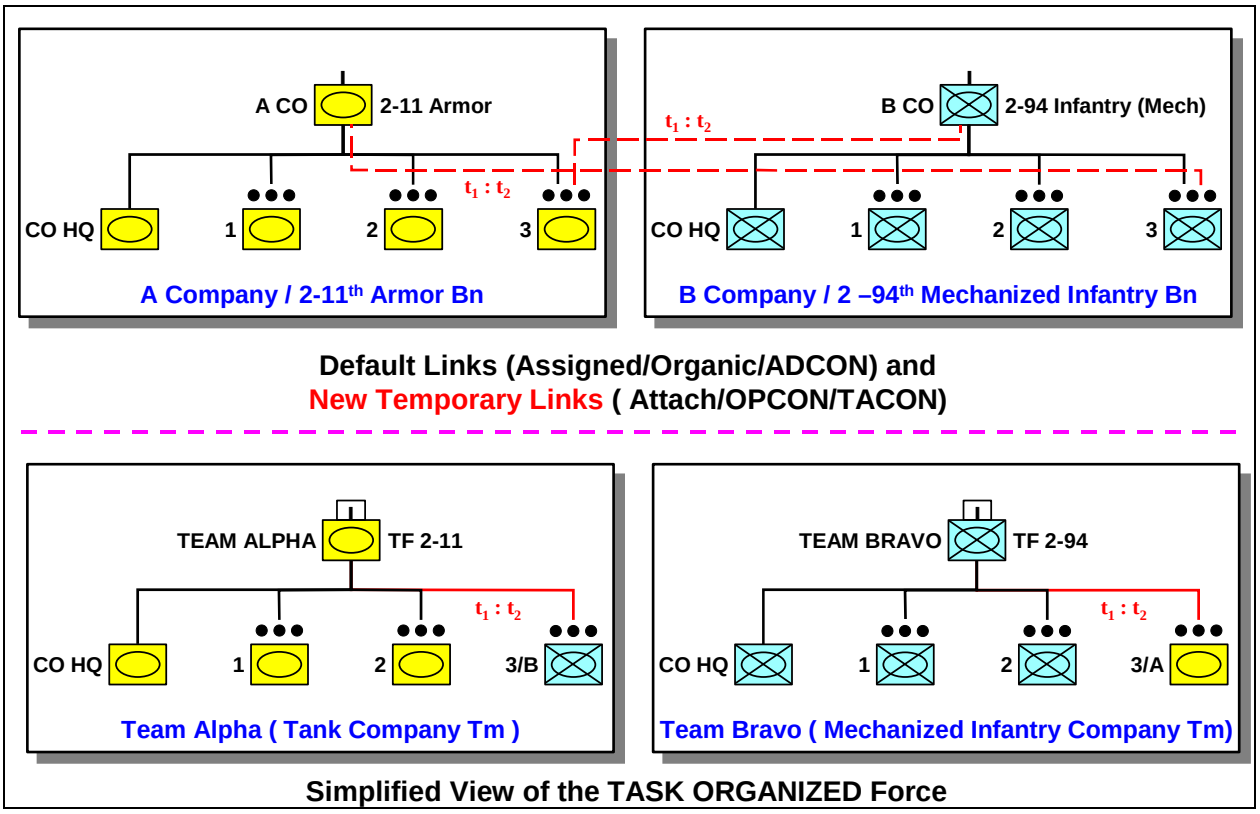

Figure 5: Complete View (Top) and Task Organized View (Bottom)

The major feature and impetus of the default force structure tree is the ability to re-link the set of DOOs into arbitrary task organized units. It is expected that many systems have the default force structure preloaded as initialization data. Therefore, only the new links have to be exchanged to define the new task organization. This is illustrated in **Figure 5** using two org trees, each composed of five DOOs. The top view shows both the default command structures (with solid black lines) for each tree and a new, temporary link (a dashed red line) that is viable between times t_1 and t_2. Notice that adding the temporary links (e.g., attachment) does not affect the existence of the default command structure (e.g., assignment).[17] The lower view is simplified to show only the active links during the task-organized period. It also includes the temporary aliases that accompany the task-organization. A major advantage of defining a set of stable nodes is that task organizing does not change the identity of the nodes; it only changes how they are linked. Using the force structure vernacular presented earlier, no new organizations are created; they are just re-linked via a different command structure, thus creating a new unit (org tree). If one traverses the unit's command structure during the period of task organization, a different set of links is traversed that connect a different set of organizations than when the unit is not task organized.

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17 *Assign* (DOD, NATO): To place units or personnel in an organization where such placement is relatively permanent, and/or where such organization controls and administers the units or personnel for the primary function, or greater portion of the functions, of the unit or personnel.
Attach (DOD): The placement of units or personnel in an organization where such placement is relatively temporary. From: http://www.dtic.mil/doctrine/jel/doddict/.

Because many other entities are associated to the set of DOOs, re-linking them retains these other associations. Therefore, the associated authorization information, status information about personnel and equipment, and geographic information remain intact and can be filtered using the basic parameter of time. The number and type of associations that may be added to the default force structure is limited only by ones imagination. The set of DOOs and default command structure maintained in the Service org servers is intended to be merely a starting point.

3.3 GFM-FSC – Roles

A *role* is an attribute of a link that provides a description of the function or purpose of the link; in other words, it is a name for a link. Roles are common and may be easily confused with DOOs. **Figure 6** illustrates a familiar example of roles in a Marine Expeditionary Unit (MEU). The top structure shows a misrepresented view where the Command Element (CE), Ground Combat Element (GCE), Air Combat Element (ACE), and MEU Service Support Group (MSSG) are depicted as DOOs. In reality, these are not real organizations, but functions an organization performs in an MEU. The correct representation is depicted in the bottom view. In this case, Battalion Landing Team (BLT) 1/6 performs the role of GCE.

Roles are an integral part of aviation unit representations, and in particular, are required to correctly characterize crews. As defined earlier, the reason for crew organizations is to provide aggregation points for equipment that requires operation by one or more persons.[18] Crew membership may be habitual or non-habitual. In the habitual case, membership is defined by a fixed set of organizations. For example, in an Army armor unit, the tank crews are composed of specific billets. This represents the practice of the same team of soldiers always working together.

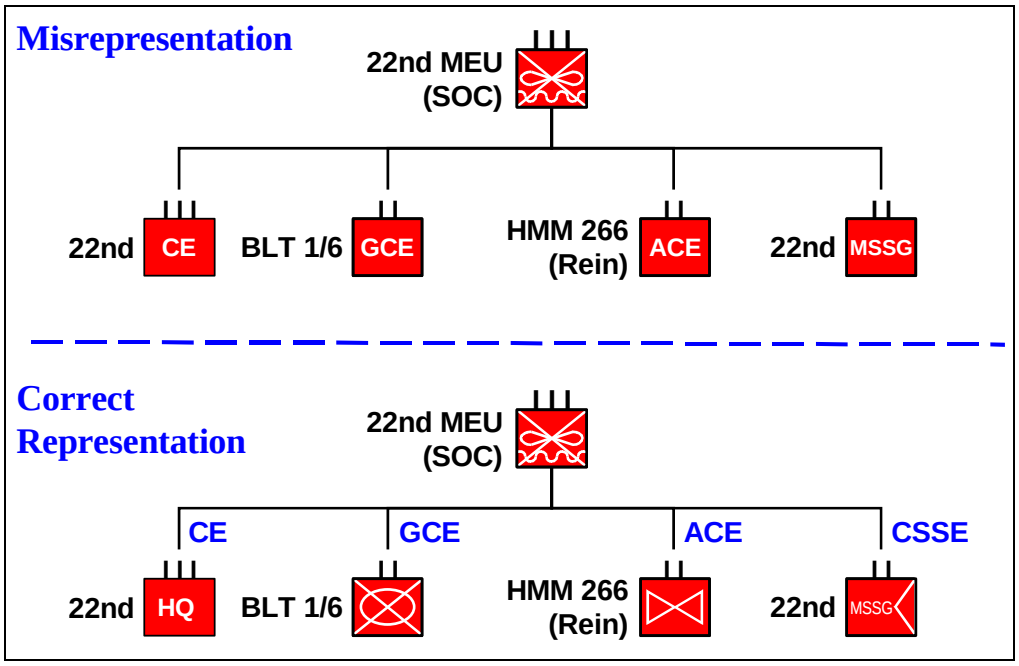

Figure 6: Example of Roles in USMC MEU MAGTF

[18] The equipment also provides transportation for the crew. But this is not part of the current definition. It would not be technically wrong to consider an infantry machine gun team a crew rather than a doctrinal organization.

Similarly, the association between a crew and its equipment, called *alignment*, may be habitual or non-habitual. Army tank crews also have habitual alignment with a particular vehicle, so the same soldiers work together on the same vehicle. However, this is clearly a special case.

Roles are key to describing non-habitual relationships, both default and actual. They allow one to create a link from a parent DOO without specifying the child and to reserve a set of links to sub-units for pre-define purposes. **Figure 7** illustrates the use of roles to describe a default USAF AWACS crew.[19] In this case, the roles are used to describe the potential composition of the crew. Many of the links have labels that describe the purpose of the organizations, indicated with dashed boxes, to be attached to the various crew teams (doctrinal organizations). When a mission package is created, billets from the squadron's flights are inserted into the crew structure via these roles (i.e., they replace the dashed line placeholders).[20] Similarly, a link is created to associate an airframe (materiel) with the crew, as indicated by the dashed (red) arrow between the aircraft silhouette and the crew organization. Therefore, one can traverse the org tree, beginning with the crew node, for a specified time to produce the crew for that instance in time. Because an airframe is associated with the crew organization, and people are associated with the billets, one can easily derive a list of crewmembers names onboard the aircraft by traversing the org tree and collecting the desired associated data. The difference is merely in the representation inside the computer.

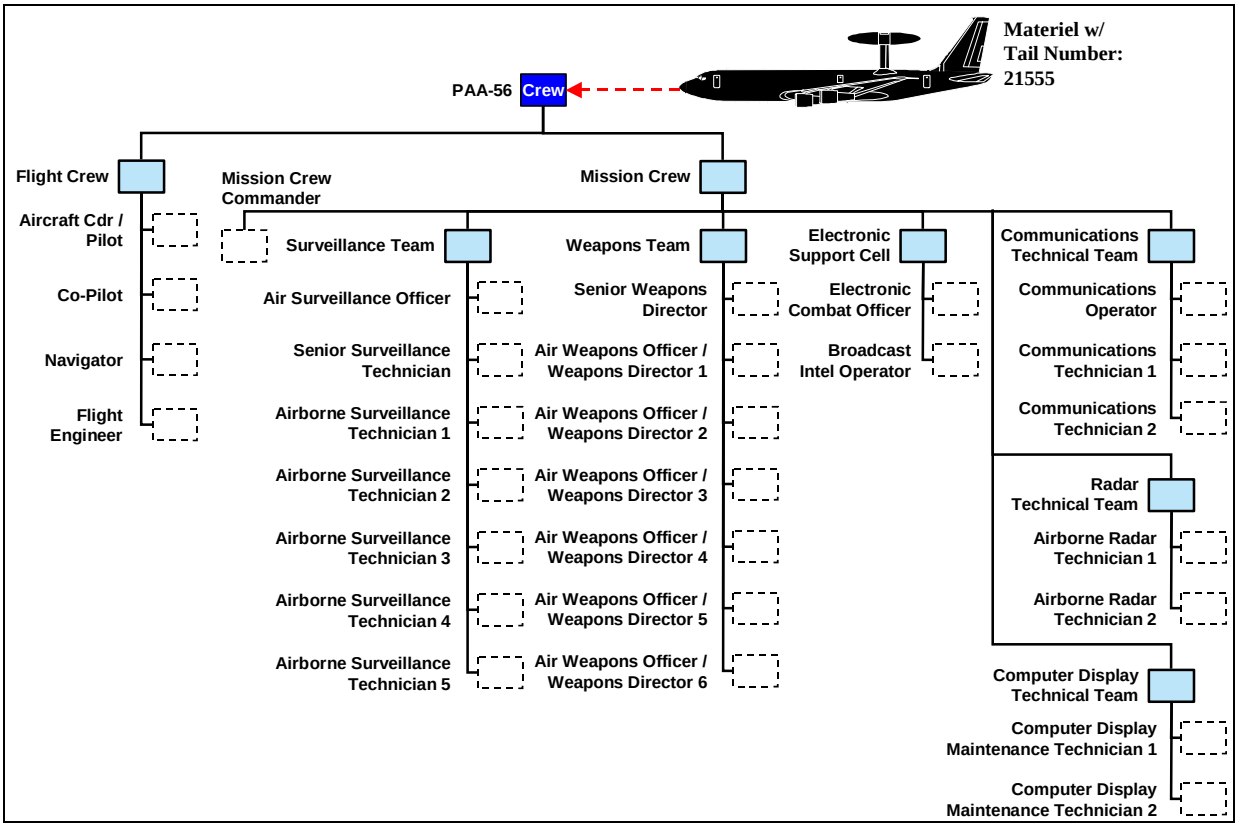

Figure 7: A Default USAF E-3 AWACS Crew Utilizing Roles

[19] AWACS: Airborne Early Warning & Control System.

[20] Technically, a new link is created for the role with a time interval commensurate with the duration of the mission. These links can be retained to provide a historical record of the crew composition.

Using the GFM-FSC, an org tree is used as the integrating and mediating structure rather than directly associating people with equipment.

This example illustrates that default force structure can be defined using DOOs *or* roles (i.e., either nodes *or* links), and these org trees can represent default administrative or operational structures. Therefore, even though the administrative and operational structures may be very different, for example, in the UASF AWACs case, this does not cause a representation problem. **Figure 8** illustrates a default administrative structure for a USAF AWACS squadron that includes crew organizations as depicted in **Figure 7**.[21] This example shows one of many alternatives for adding the crew organizations to the force structure (typically, one per prescribed authorized or present airframe). In this case, the crews are added to an operations squadron, but they could be added anywhere within the wing structure. The five Flights, labeled A through E, contain the 300 plus authorized billets that are used to deploy crews (i.e., "plugged-in" to the roles). There may be additional doctrinal organizations within this structure, but they are not included in the UMD.[22]

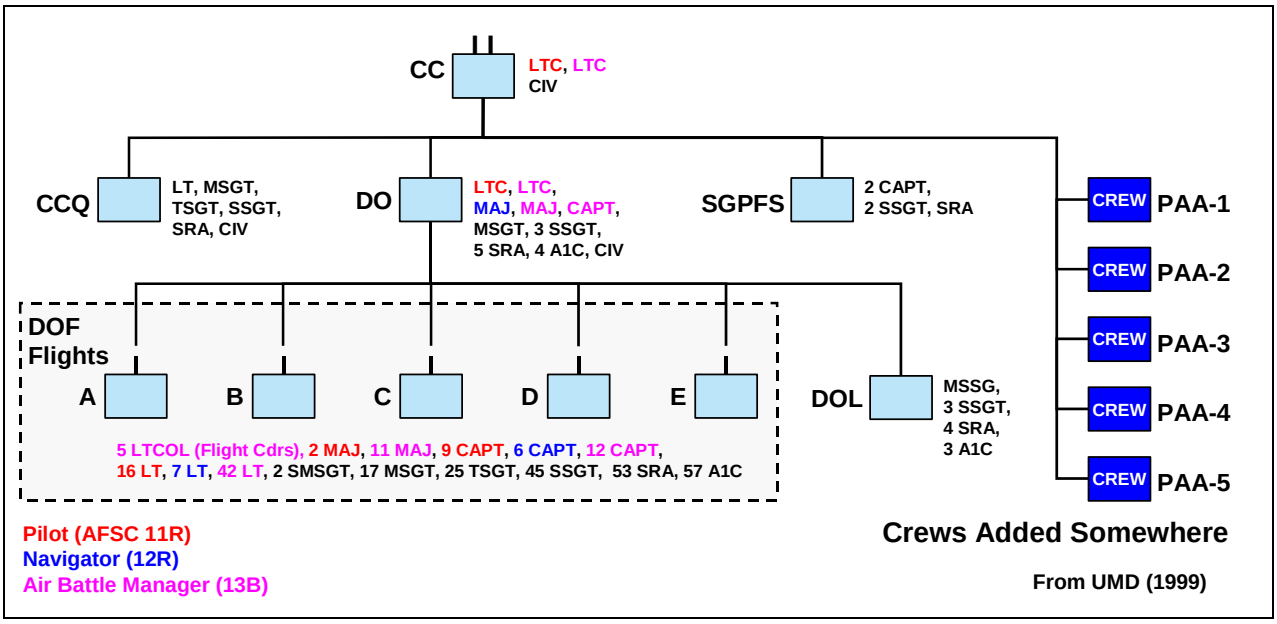

Figure 8: Administrative Structure with Crews Added

3.4 Example

Figure 9 illustrates the application of this representation for building a strike package. This example uses a template (i.e., a TO) for a MARINE FIGHTER/ATTACK SQUADRON (ALL-WEATHER) VMFA(AW) that includes F/A-18D fighter aircraft. The template must be converted into a default force structure for a real unit, in this case, VMFA(AW)-224; this requires three modifications.

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[21] The resolution of the org tree is limited to that provided by the USAF UMD; hence, the positions with multipliers.

[22] An excellent example of both administrative and operational command structures existing in the same document are USN Ship Manpower Documents (SMD) that include the DOOs in an administrative structure and use roles to define the battle bill that is an operational structure. For a pictorial example, see ARL Report: *ARL-TR-2172,* *http://www.arl.army.mil/~wildman/PAPERS/tr2172.html*, pp 44, 45.

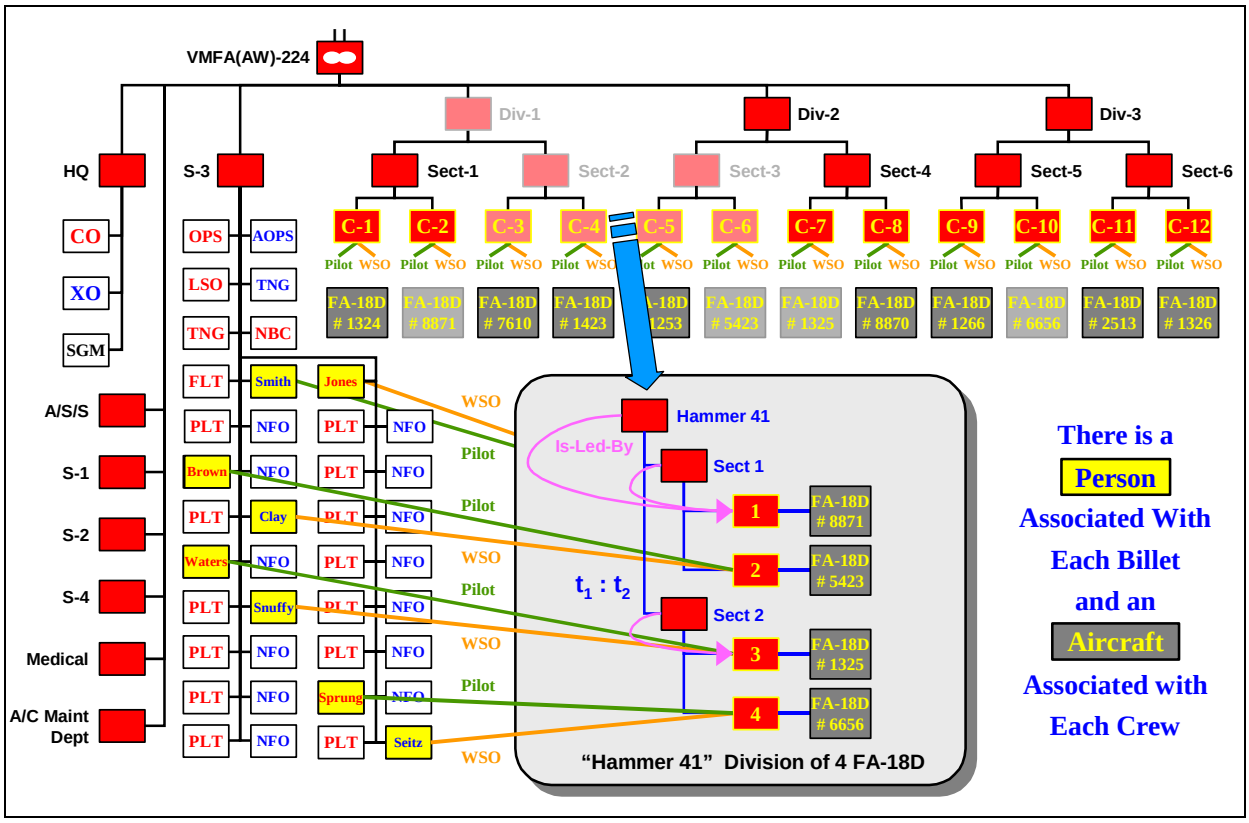

Figure 9: Creating a Strike Package Using DOOs and Roles

First, multipliers must be expanded to change positions into billets.[23] For example, most of the aviators are located in the "S-3 Section" where the template indicates that 8 naval aviators are authorized via a position named "pilot" with the rank of CAPT, the primary Military Occupation Specialty (MOS) of 7523 (Pilot VMFA F/A-18 Qualified) and the skill designator 7527 (F/A-18D Qualified). This position data must be expanded into eight separate billets to which people can be assigned. In **Figure 9**, under the S-3 Section, 15 positions with multipliers have been expanded into 41 billets (shown). Second, a crew organization is created for each authorized aircraft, in this case, 12 crews. Each crew has two roles attached, one named Pilot and one named Weapon Systems Officer (WSO). Finally, doctrinal organizations are created to reflect common tactics, techniques and procedures. Aircraft are normally deployed in pairs or larger groups. A pair is called a Section, so a Section is created for every two crews. Finally, a Division is four aircraft and is often deployed as two sections, so a division is created for each pair of sections. This set of additional organizations converts the USMC TO template into a default force structure composed of the DOOs normally employed to conduct flight operations.

To create a strike package, the default force structure can be rearranged and augmented to represent this structure. Using the principle of stable nodes and dynamic links, a subset of DOOs from the default force structure are recombined using a new set of links. All links include a time

[23] In personnel vernacular, a *position* provides a description of a job and may have multipliers associate with it; for example, "authorized 8 riflemen." A *billet* is a specific job that may be filled by a person; for example: the preceding position description can be expanded into eight billets: "Rifleman-1" through "Rifleman-8."

interval that designates them as viable during the life of the strike package, in this case, between times t_1 and t_2. This example builds a four aircraft strike package. First, a foundation is created by selecting three doctrinal organizations (i.e., Div-1, Sect-2, and Sect-3) to be connected together via two new links. For the designated time period, the doctrinal DOOs are given the aliases of "Hammer 41," "Sect-1," and "Sect-2," respectively. Next, four crew organizations are selected and placed under the sections using four new links, also viable between times t_1 and t_2, and are given the aliases Crew 1 through 4. Billets are "plugged-in" to the roles for each crew to designate the members of the package. Because people are associated with the selected billets, this inherently assigns people to the crews. Next, airframes are chosen and aligned with crews. This ultimately associates people with aircraft. The essential difference is that, perhaps unknown to the user, the association between the aircrew and an aircraft is implemented via a small org tree using the GFM-FSC. Finally, mission command may be defined via another set of links called "is-led-by" links.[24]

Combined together, one can now use the small unit (an org-tree) defined by the organization nicknamed "Hammer 41" as an integration point for a wide variety of data. For example, the four aircraft can be tracked as individual aircraft, two sections, or a division. Similarly, missions and targets can be linked to any or all of the seven DOOs employed in this strike package. Notice that the identity of the DOOs does not change from the default. If one did a search of all the links that connect to these DOOs, there may be many results. However, when filtered using the parameter of time, the sets of operational links should be mutually exclusive, thus providing a historical record of how the DOOs were employed. The stable nodes provide the persistence required to continuously track military operations, while the time-tagged dynamic links provide complete flexibility to create any task organization that complies with the basic semantics of the GFM-FSC.

3.5 Data Modeling and Models.

To effectively implement an organization server, a formally represented, unambiguous data model must be defined. The GFM-COI will select a data model in the near future. Fortunately, several models exist that include a majority of the data entities required by an org server. The two models receiving special scrutiny are the Command & Control Information Exchange Data Model, or C2IEDM, and the Core Architecture Data Model, or CADM.[25] Both of these models evolved from the Generic Hub (GH) series of models developed in the Army Tactical Command & Control Information System, or ATCCIS program.[26] The C2IEDM is also known as the GH Version 6, or GH-6. A small subset of entities from these models can provide the minimum set of entities to implement an org server. Further, the subsets of entities (and their attributes) from the two models are almost identical.

The GH series of models incorporate five basic battlefield domains: organization, materiel, person, feature, and facility. Each domain includes both instance data (i.e., real objects) and class

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[24] The use of an "is-led-by" link between an internal nodes of an org tree and a billet is described in the reference provided in footnote 5, page 2.

[25] C2IEDM, see http://www.mip-site.org;
CADM, see: http://www.c3i.osd.mil/org/cio/i3/AWG_Digital_Library/index.htm

[26] ATCCIS, see: http://www.mip-site.org/ATCCIS/ATCCIS_Home.htm.

data (i.e., descriptive *type* objects) that have the suffix "-type."[27] Therefore, there is a set of entities called organization-type, materiel-type, person-type, etc., that provide general descriptions of their real counterparts. It is common for many instances to share the same type definition. For example, in the materiel domain, for a particular type of materiel there are often many real objects (materiel) with serial numbers of that type. Every real materiel entity references a materiel-type entity that contains the general description of that real object; this might include its category as defined in the Federal Supply Catalog and include a National Stock Number (i.e., NSN). An analogous condition occurs with all the basic battlefield domains.

Initially, the org servers will include data only about three of these domains, organization, materiel, and the person, as is illustrated in **Figure 10**. This over-simplified illustration uses a graph of nodes and links to depict the major entities used in a GH-based model. The nodes represent the basic battlefield entities and the links represent associations between them. When actually implemented, both the nodes and links are maintained within tables or objects.

An org server will contain authorization data (i.e., the ideal case) and not information about real object, such as people (i.e., person) or equipment (i.e., materiel). This is depicted in **Figure 10** by the exaggerated boundary isolating the right-most column of nodes (included for clarity). Entities to the left of the boundary are included in an org server. Instead of real people and equipment, an org server includes information about the quantities of authorized types of equipment (materiel-type, or Mat_Type) and the qualifications required (person-type, or Pers_Type) of the people who occupy billets. Examples of these entities reside in the left-most column of the figure.

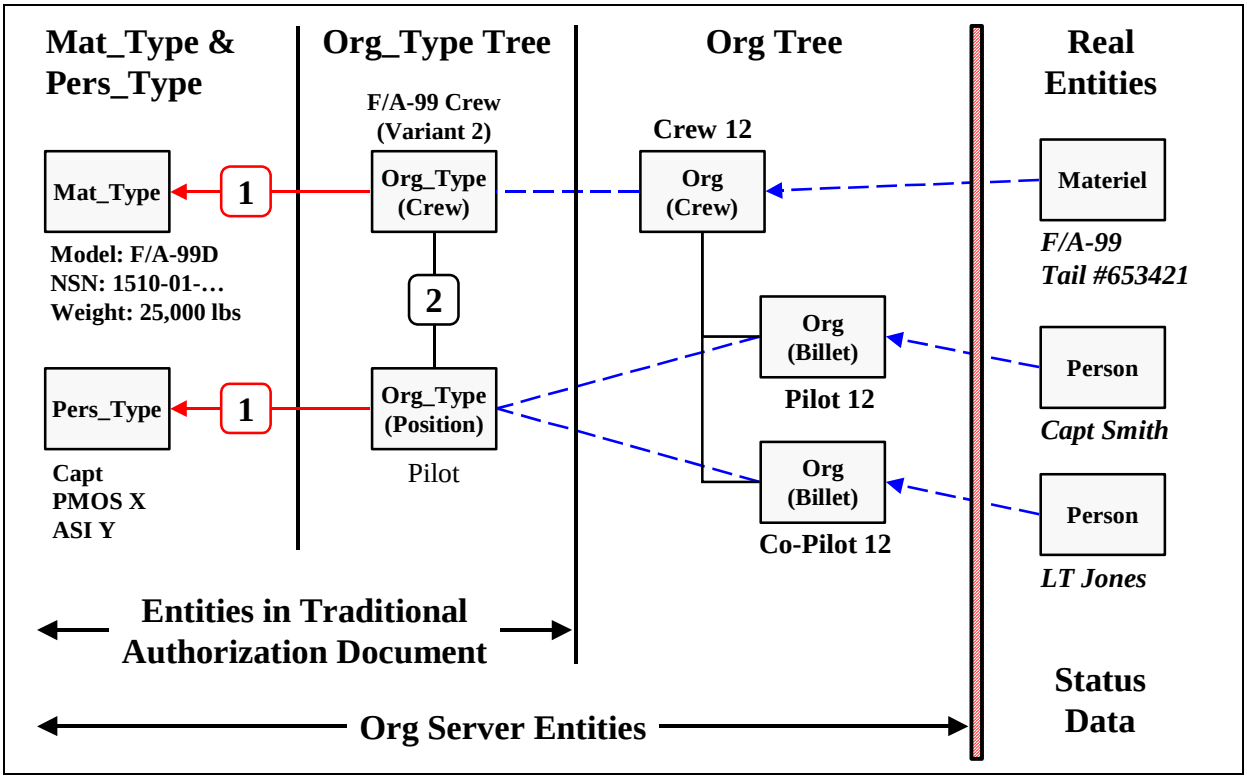

Figure 10: Basic Entities in an Org Server

[27] The models use the super classes *object-item* for instances, and *object-type* for classes.

The foundation of the server is the organization domain, and both organization and organization-type entities are included as trees in the center two columns of the figure. Recall that Org_Type entities are used to represent the organizational templates from which real organizations are established. Routinely, many organizations are established from a common template. A key feature of the "type" entities is the presence of multipliers in the associations between them. These multipliers are not present in the instances.

Figure 10 presents an over simplified example of a fictitious "F/A-99 Crew." The Org_Type tree describes a generic crew template for a variant that contains two pilot positions as indicated by the multiplier in the default link between the two Org_Type nodes. Verbally, one would state: "A default F/A-99 Crew (Variant 2) is-composed-of two Pilots." Further, to occupy a pilot position, one is required to hold the rank of Captain (Capt), and have the primary MOS of X and an additional skill designator of Y, as is defined within the associated Pers_Type entity that is linked to the Pilot Org_Type entity as depicted by the (red) solid arrow between them. It may appear unnecessary to have a multiplier in this link, but in the general case a multiplier may be any value. The multiplier of "1" is an artifact of extending the FSC down to the billet level. Similarly, a default F/A-99 Crew (Variant 2) is authorized one F/A-99D aircraft (as depicted by the (red) solid arrow).

The most distinguishing feature of an org server, and the foundation of the GFM-FSC, is the org tree. Traditionally, authorization documents have been templates from which real organizations are established and, in this example, are represented by the "-type" nodes and links in the left two columns. Often, real units were defined by adding a list of UICs to an authorization document to identify the real units that are to use the template. Thus, the UIC boundary was reinforced between the upper and lower tiers via the use of authorization documents. Org servers change this by adding a new structure composed of DOOs and a default command structure expanded from the org template. This is the default org tree. Every org (node) must reference the Org_Type (node) from which it is established. This is depicted in the figure by the dashed line between the org and Org_Type nodes. This link is often referred to as an "is-a" link because it can be verbally stated as "Crew 12 *is-a* F/A-99 Crew (Variant 2)." Using this link, the "Crew 12" org entity inherits all the properties of the corresponding "F/A-99 Crew (Variant2)" Org_Type.

An org tree has no multipliers. Individual links to trackable nodes replace the links with multipliers that are incorporated in Org_Type trees. This allows people and real equipment to be associated with specific org tree nodes as is depicted in **Figure 10** by the (blue) dashed arrows representing the associations between the org entities and materiel and person entities. In this example, the Pilot position with a multiplier of two is expanded into two billets, one named "Pilot 12" and the other named "Co-Pilot 12."[28] To these billets, real people may be assigned. In this example, external to the org server, Capt Smith is assigned to billet "Pilot 12" and Lt Jones is assigned to the billet "Co-Pilot 12." Note that one can derive that Lt Jones is supposed to have the rank of Captain to be qualified to occupy the billet. These types of anomalies are common.

A subset of entities exists within the C2IEDM and the CADM to handle the data representation requirements for an org server. Additional attributes may have to be added to the entities, but the

[28] Recall footnote 23, page 2.

data models already include all the entities (nodes) and associations (links) required to represent org trees, Org_Type trees, Mat_Types, Pers_Types, and their relationships.

3.6 Summary of GFM-FSC Precepts

An organization is a virtual entity. It doesn't physically exist. It is simply a mental grouping of real objects that reflects a person's perception of the structure. For this reason, it is rare for two people to create semantically similar organization structures. Therefore, to improve consistency, interoperability, human assimilation, and machine manipulation, it is beneficial to develop and publish a set of precepts concerning the representation of organizational structures. The following is a basic, but not comprehensive, set of construction guidelines.

3.6.1 An organization chart should be a tree graph, called an org tree.[29]

Every node must be connected to a parent, except the root node whose parent is itself. A node with children is called an internal node; a node without children is called a leaf node. A set of parameters must exist such that for any given time only a single path exists between any two nodes. Pragmatically, this requires that every org must have a default parent identified.

3.6.2 Terms

Organization: a node of an org tree.
Command Relationship: a link of an org tree used to represent composition; it is verbally interpreted as "is_composed_of."
Command structure: a set of command relationships used to represent aggregation.
Unit: a tree graph composed of a set of organizations and a command structure.
Default Operational Organizations: a complete set or organizations used to perform the expected tasks required of a unit.
Default Command Structure: A command structure depicting the organic composition of a unit's default operational organizations.
Role: a named given to a command relationship to define or distinguish its purpose. The command relationship is not required to have a child node (i.e., it may be used as a placeholder or template).

3.6.3 Time

Every organization and command relationship will include a time interval, based upon real time, to denote the time period that the entity is viable. This will allow filtering based upon real time. Recommended attribute names to define the interval are *s_time* (start time) and *t_time* (termination time). The term effective time (or date) is avoided because it already has several preconceived meanings.

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[29] For a formal definition of a tree, see http://en.wikipedia.org/wiki/Tree_(graph_theory)#Definitions, or Knuth, Donald E. *Fundamental Algorithms(Vol 1) - The Art of Computer Programming (2nd Ed).*; Addison-Wesley Publishing Company, 1973; ISBN 0-201-03809-9; Page 305.

3.6.4 Categories of Organizations

An organization should have a reason for being entered into a tree. Currently, there are three reasons for creating an organization: *Billets*: - for employing a single person; *Crews* - for employing a piece of materiel requiring operation by one or more persons; and *Doctrinal* - for employing doctrine, tactics, techniques, or procedures. Recall page 2 for additional information.

3.6.5 Resolution

Org trees will extend down to the billet level and include the crews and doctrinal organizations required to perform expected, routine operations. This applies to the Active and Reserve components, civilian, and conceivably, contractor organizations or personnel.

3.6.6 Crew Terms and Semantics

A crew should be created for each asset (i.e., platform) expected for a unit. For example, every ship, aircraft, or drivable vehicle should have an associated crew.

Assignment: the process of building crew membership.
Alignment: the process of creating associations between entities of the materiel domain and a crew (i.e., linking equipment to a crew organization).

Crew assignment and alignment are independent processes and may be habitual or non-habitual. Non-habitual assignment may be implemented using roles. This commonly occurs in aviation crews where roles are used to define the functions of their transitory members.

3.6.7 Mandatory and Optional Associations

At a minimum, a default force structure will be provided that consists of a set of default operational organizations and a default command structure that depicts the organic structure of an unit. The choice of optional associations within the organization domain is limited only by the imagination of the developer. Two common sets of optional links are a default operational command structure and “is-led-by” links.

The default operational command structure depicts additional habitual command relationships or well-known alternative command structures. The only requirement is that the command relationships be clearly annotated to allow traversal using any additional set of associations (e.g., an administrative versus operational command structure).

Examples of these abound. US Navy Ship Manpower Documents contain both an administrative command structure (composed of Departments, Divisions, Work Centers, and billets) and the Battle Bill that depicts the operational command structure during battle stations. The Battle Bill includes no billets, but uses roles that specify the requirements for billets to fill the role (from the administrative command structure). Similarly, Army units have well-known habitual relationships, such as those between the elements of a direct support artillery battalion and its supported maneuver brigade. These associations can be easily added to the default force structure.

Another, more advanced association is the ”is-led-by” association. A basic military condition of any crew or doctrinal organization (i.e., an internal node) is that someone is always in charge of that aggregation of organizations (i.e., the people and equipment). A useful requisite is to require that every active internal node have a default “is-led-by” association added to identify the default billet that is nominally in charge of the unit rooted by the internal node. If one is not identifiable, then the internal node should not be added. The term “active” is used because an internal node may incorporate roles without children nodes (i.e., serve as placeholders). When the roles are filled, the internal node becomes active and an is-led-by link must be added. It is permissible to designate a role as a default is-led-by link (e.g., “the pilot of a crew is always the leader”).

4. Summary

Global operations in a network centric environment require high-resolution, richly populated force management data, constructs and management processes that extend across Service boundaries. This paper presents an approach to implement a set of organization servers across the DOD to allow the sharing of detailed, accurate, force structure data that extends down to the billet level.

Realistically, the only way to maintain this level of force structure data is to obtain it directly from the agencies responsible for building and maintaining that data. This requires that the people who develop and maintain force structure data in the Services and for the DOD must provide it in a form conducive to computer manipulation for use by a diverse population of users. The list of systems that require this data is large and includes the areas of battle command, logistics, personnel, readiness, communication, information security, and planning and budgeting. Therefore, the servers and the data they contain must be designed so that a diverse set of developers can automatically obtain and manipulate the data to transform it into the products require to conduct business in their environments. This requires a formal and rigorous approach be used to define and maintain the information.

The assertion is presented that the central theme through which all battle command processes converge is the fundamental concept of *force structure*; consequently, it can be used as a foundation, or bridge, to integrate other battle command concepts and data. To help achieve this, a set of basic precepts was presented that define how to represent force structure data in a form that is Service independent. This extends beyond a data-modeling task. Organizations are virtual entities that do not physically exist. They are simply mental groupings of real objects that reflect a person’s perception of the structure. Given a particular data model, that data can be instantiated from many different perspectives. The precepts provide a small amount of discipline to simplify this task to increase the ability to understand and exchange the data, preferably by machines. Two primary precepts are: one, to formally represent force structure as sets of organization trees, and two, to include doctrinal, crew, and billet entities as organizations in those trees. This allows information about people and equipment (i.e., the primary resources of the DOD) to be tightly and unambiguously coupled with the operational domain. Further, this provides a consistent, unified structure that extends down, beyond the current UIC boundary, to the billet level to which any information may be associated.

It is the actual force structure data, not its theory or a model, which is required by battle command and other system users. Historically, in the absence of data, those in need create it themselves. Force structure data is no different. As a result, there are many different sources of force structure data available throughout the Services, in various forms and different levels of detail. Clearly, they are not synchronized and require extensive effort to keep current. The GFM-COI is confronting this challenge. This includes an aggressive set of milestones to produce GFM data for the net-centric environment that is accessible by the combatant commanders, across the Services, and ideally, among coalition partners.